DEPARTMENT OF MECHANICAL ENGINEERING
GEORGE R. BROWN SCHOOL OF ENGINEERING
RICE UNIVERSITY

MECH 497/597: ENGINEERING MECHANICS (3 Credits)
Fall 2018

SECTION I. CONTACT INFORMATION

- Instructor: B.J. Fregly, Ph.D.
- Office: Mechanical Engineering Building 203
- Email: fregly@rice.edu
- Office Hours (MEB 203):

  Mondays: 1:00 PM - 2:00 PM

  Wednesdays: 2:00 PM - 3:00 PM

  Fridays: 11:00 PM - 12:00 PM

- Grader: Nick Jean-Louis
- Office: MEB 112
- Email: nick.jean-louis@rice.edu

SECTION II. COURSE INFORMATION

- Pre-requisites: MECH 211 and CAAM 210 (or by permission of instructor)
- Lecture Schedule:

  Monday, Wednesday, and Friday: 10:00 AM – 10:50 AM
- Location:

  Mechanical Engineering Building 128
- Required Textbook:

  Myer Kutz. Standard Handbook of Biomedical Engineering & Design. McGraw Hill Access Engineering, 2018. Available for free online at: https://www.accessengineeringlibrary.com/browse/standard-handbook-of-biomedical-engineering-and-design

  Chapter 5: BIOMECHANICS OF HUMAN MOVEMENT

  Chapter 6: BIOMECHANICS OF THE MUSCULOSKELETAL SYSTEM

  Journal articles assigned as required reading will be made available through Canvas.
- Required Software:

  OpenSim version 4.0 beta (Windows and Mac) musculoskeletal modeling software. Available for free on-line at:

  https://simtk.org/projects/opensim

  Notepad++ (Windows) or BBEdit (Mac) text editor. Available for free online at:

  https://notepad-plus-plus.org/

  https://www.barebones.com/products/bbedit/

  Matlab (Windows or Mac). Available for free from Rice.

- Web-based Teaching Materials:

  Dr. Scott Delp's lab at Stanford University has developed a wealth of teaching materials on musculoskeletal computer modeling and simulation using the OpenSim software developed by his research group. Available for free online at: https://simtk-confluence.stanford.edu:8443/display/OpenSim/OpenSim+Documentation

- Teaching Philosophy:

  If interested, you can read my teaching philosophy on my lab website:

  http://rcnl.rice.edu/PDFs/teaching_philosophy.pdf

- Teaching Methodology:

  The instructor will utilize PowerPoint presentations, the whiteboard, and interactive software demonstrations to facilitate learning in this course. Students are strongly encouraged to ask questions during class. The only dumb question is the question that you don't ask! Each lecture, the instructor will provide an outline of the concepts to be covered so that students will know where they are in the course material. Class notes will be posted on Canvas after lecture. We will have a number of "Simulation Fridays," where students will bring their laptops to class and work with the instructor on various modeling and simulation exercises. If you do not have a laptop, you will need to work with another student in class who has one.

- Course Description:

  Introduction to computer modeling and simulation of the human neuromusculoskeletal system. Topics include measurement of human movement, 3D kinematic modeling, inverse and forward dynamic simulations, muscle and joint contact force estimation, and neural control modeling. Programming proficiency in Matlab required. Graduate/Undergraduate Equivalency: MECH 597. Mutually Exclusive: Credit cannot be earned for MECH 497 and MECH 597.

- Course Design:

  This course is modeled after the graduate course ME 382 "Modeling and Simulation of Human Movement" developed by Dr. Scott Delp at Stanford University. Variations of this course are also taught at the University of Texas at Austin, the University of Wisconsin, Wake Forest University/Virgnia Tech, and the University of Tennessee. The instructors from each of these courses (including the present course at the Rice University) have agreed to share all course materials in order to create a world-class instructional opportunity. Consequently, you will be benefiting from extensive work done by instructors at six institutions while taking this course.

- Course Purpose:

  The goal of this course is to teach you how to develop dynamic models, analyses, and simulations of the human neuromusculoskeletal system for different types of movement. Learning will be achieved through a series of traditional lectures, interactive modeling and simulation lectures, simulation laboratories, and simulation projects. The focus will be on the system involved in producing voluntary movement - the human neuromusculoskeletal system. Mathematical models will be developed for each component of the system and implemented in the OpenSim musculoskeletal modeling software, with some models also implemented in Matlab. Students will create models, perform computer simulations, and analyze the results to gain insight into movement biomechanics and control.

- Course Objectives:

  By the end of the course, you should be able to do the following:

  – *Neuromusculoskeletal modeling*. Develop complex three-dimensional musculoskeletal models, develop muscle-tendon models possessing force-length-velocity properties, and

develop neural control models that emulate the characeristics of the human motor control system.

- *Neurousculoskeletal analyses*. Calculate joint motions and muscle moment arms from experimental surface marker data, calculate joint moments from experimental force and motion data using inverse dynamics principles, predict muscle forces and activations during movement using optimization principles, and analyze the inter-depencence of experimental muscle EMG signals using muscle synergy analysis.
- *Neuromusculoskeletal simulations*. Create forward and inverse dynamic simulations of musculoskeletal motion that reproduce experimental movements or predict new movements for which no experimental data are available.

- Absence Policy:

  The instructor is aware that the students participating in **university-sponsored** extracurricular activities may, on rare occasions, need to miss a lecture during the semester. In such cases, it is the student's responsibility to notify the instructor in advance to arrange make-up work and lectures.

- Topics Covered:

  The course will be divided into four main parts:

  1) Preliminaries
  2) Skeletal modeling
  3) Muscle-tendon modeling
  4) Neural control modeling

  By the end of the course, you will be able to put the four parts together and be well prepared to pursue future projects involving neuromusculoskeletal modeling.

SECTION III. GRADING POLICY

- Grading:

  Since this course is built around computer simulations, grading will involve primarily simulation labs and simulation projects. Students enrolled in MECH 497 will be graded as follows:

Class Participation/Attendance	10%
Simulation Labs/Homework Assignments	45%
Simulation Projects	30%
Exam	15%

  One take-home exam will be given covering the basics of skeletal kinematics and dynamics.

  Students enrolled in MECH 497 will complete two well-defined simulation projects. Students enrolled in MECH 597 will complete the same simulation projects along with a third more open-ended simulation project to be defined in consultation with the instructor.

- Collaboration

  Students are encouraged to work in groups on homework assignments, simulation labs, and simulation projects. HOWEVER, direct copying of another student's work is not permitted, and each student must submit his or her own work.

  Late homework, lab, and project assignments will not be accepted. However, since difficult weeks will arise during the semester, each student will be permitted two late assignments turned in not more than one week after the original due date. No prior notice need be given to the

instructor when you choose to cash in a late homework. Hardship cases will be considered on an individual basis only if the instructor has been contacted *before* the due date of the assignment.

- Attendance

  Students are expected to attend all lectures. Since much of the course material is not available in any textbook, it will be critical for students to attend lectures regularly.

- Grading

  Course Grades:

A+	98-100
A	93-97
A-	90-92
B+	87-89
B	83-86
B-	80-82
C+	77-79
C	73-76
C-	70-72
D+	67-69
D	63-66
D-	60-62
F	below 59

  For individuals in the gray area between two grades, performance on homework assignments will be used to make the final decision.

SECTION IV. HOLIDAYS - NO SCHEDULED CLASSES

1. Labor Day (Monday) 09/03/2018
2. Midterm Recess (Monday) 10/08/2018
3. Thanksgiving Break (Friday) 11/23/2018

SECTION V. UNIVERSITY POLICIES

- Rice Honor Code:

  All student conduct associated with this course must comply with the Rice Honor System. While participation in study groups is strongly recommended, the work that you submit for grading must be your own. This policy applies to homework assignments and exams.

- Rice Disability Support:

  Any student with a disability requiring accommodations is encouraged to contact the instructor outside of class. Information regarding disability accommodations and other support can be obtained at http://www.dss.rice.edu/.

- Syllabus Policy:

  Information contained in the course syllabus, other than the Absence Policy, may be subject to change with reasonable advance notice, as deemed appropriate.